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Low Vision Simulation in Virtual Reality for Training Empathy within Eye Care Providers

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Abstract:

VR (Virtual reality) has been found an innovative technology that allows health care providers to simulate being a patient with sensory impairments. This study aimed to develop a set of VR software of low vision simulation for eye care providers. The application is based on VR, fully immersive, with gamification and interactive designs. It uses 3D Max and Unity as development tools, and uses C# as the programming language. The solution of Stream VR+HTC Vive Pro makes head movement, hand movement, and body tracking integrated to ensure accurate completion of tasks. Voiceover instructions and background music are also incorporated to match the theme. In the study, 5 low vision symptoms were simulated into the VR application and 3 tasks were matched within each simulation. As a result, a set of visual simulation software for empathy training within eye care providers was developed. The set of low vision simulation software tools can be accessible within a standard university setting and can be used to enhance empathy education in the future.

Keywords*: Virtual reality, Simulation, Empathy training, Eye care providers, Low vision.*

I. INTRODUCTION

Empathy is the ability to sense other people's emotions, coupled with the ability to imagine what someone else might be thinking or feeling. It is proven to be important for public healthcare providers. The healthcare provider who gains the ability would step imaginatively into the shoes of patients, the compassion for patients often promotes them to provide the most optimal level of care. Empathy training is broadly applied in medical education for psychiatry residents, internal medicine residents, family medicine and gynecology residents, pediatric residents, physicians, different levels of medical students, etc. [1]

Low vision refers to vision loss that cannot be corrected by medical or surgical treatments or conventional eyeglasses [2]. As predicted by the Vision Loss Expert Group of the Global burden of disease [3], 61.0 million (52.9 to 69.3) people will be blind, 474 million (428 to 518) will have moderate and severe vision impairment by 2050. With the rapid growth of people with low vision and high demand for vision quality, optometrists as primary eye care providers should be well educated in this area. Adequate relevant training is also needed for other eye care providers such as social workers, ophthalmologists, low vision therapists, occupational therapists, teachers of the visually impaired, even related family members,

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etc. Low vision is usually permanent, generally, the current treatment for Low vision can only help one do everyday activities more easily or keep one's vision from getting worse more slowly. Besides, due to complex causes of low vision, different patients with low vision may experience various of symptoms, Patients with low vision are facing daily obstacles even in simple daily activities. It is hard to imagine that any eye care provider without empathy education could satisfy the specific needs of low vision patients. Therefore, a proper level of empathy from the eye care providers is essential for patients. Unfortunately, the importance of empathy among eye care providers is normally neglected and empathy education relevant to eye care is rarely seen [4]. Traditionally, healthcare providers accept empathy education through textbooks, watching videos, or didactic [1], One can only imagine the suffering and torture of low vision without self-experiences as a low vision patient. These facts have made it a challenge to apply empathy education to the targeted population.

Recently, a more promising approach for improving the empathy level of healthcare providers toward patients is highly recommended [5, 6], VR training for empathy is considered an effective way because it allows healthcare providers to see things through the eyes of patients [7]. Although researchers have found advantages of VR like immersion, interaction, embodiment, relatively safe environment for users for training empathy [8-10], few studies [11, 12] have made use of VR for promoting empathy for low vision within eyecare providers.

In the current study, we aimed to develop a set of VR software for low vision simulation, which could be further applied in training empathy within eyecare providers.

II. MATERIALS AND METHODS

2.1 Symptoms of Low Vision Simulation

According to Vision Rehabilitation PPP drafted by the American Academy of Ophthalmology [13], Low vision could be commonly divided into five categories: blurry or hazy vision, central vision loss, night blindness, peripheral vision loss, and contrast difficulty.

Blurry or hazy vision is very common in low vision patients. It is the loss of sharpness of eyesight, making objects appear out of focus and hazy. Blurred vision could be caused by cataracts, or high refractive error (myopia, hyperopia, or astigmatism).

Central vision loss means the one is not being able to see things in the center of vision, various sizes of spots, shadows, sight distortion are seen in patients, it can be caused by diabetic retinopathy, glaucoma, age-related macular degeneration, or retinitis pigmentosa.

Night blindness is a symptom that patients with low vision are not able to see any objects in low light. The main reasons behind it are high refractive error, retinitis pigmentosa, or glaucoma.

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Peripheral vision loss is the loss of peripheral sight. Someone with peripheral vision loss can see what is right in front of them, but they may have gaps in their side vision. Due to deterioration of glaucoma, diabetic retinopathy, or retinitis pigmentosa, finally, you may get tunnel vision.

Contrast sensitivity is essential in daily life. People with reduced contrast sensitivity may experience poor vision while driving at night or difficulty seeing curbs and steps. Glare is a special type of contrast difficulty; it is a difficulty in seeing in the presence of bright light. Contrast difficulty can be a symptom of certain eye disorders such as cataracts, glaucoma, or refractive surgery afterward.

This classification enables us to identify the software design requirements. Low vision simulation should be designed based on the five symptoms.

2.2 Tasks of Low Vision Simulation

Although there were differences in the conclusions from different researchers [13-15], The most common functional complaints were difficulty in reading, writing, and car driving, we combine tasks and symptoms of low simulation, thus we could gain a dozen of scenarios such as reading (writing, car driving) under blurry vision simulation; reading (writing, car driving) under central vision loss simulation; car driving under night blindness simulation and so on.

2.3 Low Vision Simulation Realization

2.3.1 Hardware support:

HTC Vive is a virtual reality headset-mounted monitor developed and manufactured by HTC in conjunction with Valve. It is paired with two single-held controllers and a positioning system (Lighthouse)that can track both monitor and controller in space. For the VR headset of HTC Vive Pro, the 5k resolution, 120 ˚field of view angle, and 120Hz refresh rate bring in a new generation of immersive visuals. Instead of relying on cameras, the Lighthouse uses lasers and photosensitive sensors to determine the location of moving objects, expanding the user's movement range. So we chose HTC Vive Pro as the hardware device for the low vision VR simulation.

2.3.2 Software development:

The application uses 3D Studio Max to model cars, books, characters, and other physical objects, and uses Unity to realize the simulations of 5 low vision symptoms# as a programming language to ensure the friendliness of human-computer interaction.

2.3.3 Interaction design

For a stronger virtual experience, the controls used for the tasks are mainly the standards Stream VR

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control scheme. When hovering over an object, the object will be highlighted. The task simulation operates by prompting instructions through voiceover and floating captions on the screen. The users are required to complete all the tasks within 60 seconds to complete the simulation, tasks unfinished in time are hinted at by voiceover instructions and labeled by a red cross, while the tasks completed correctly in time are labeled with green marks.

2.3.4 Tasks System

Log in to the main menu, we can choose different simulation scenarios through the controller, and we can learn the operating rules of the application (See Fig. 1).

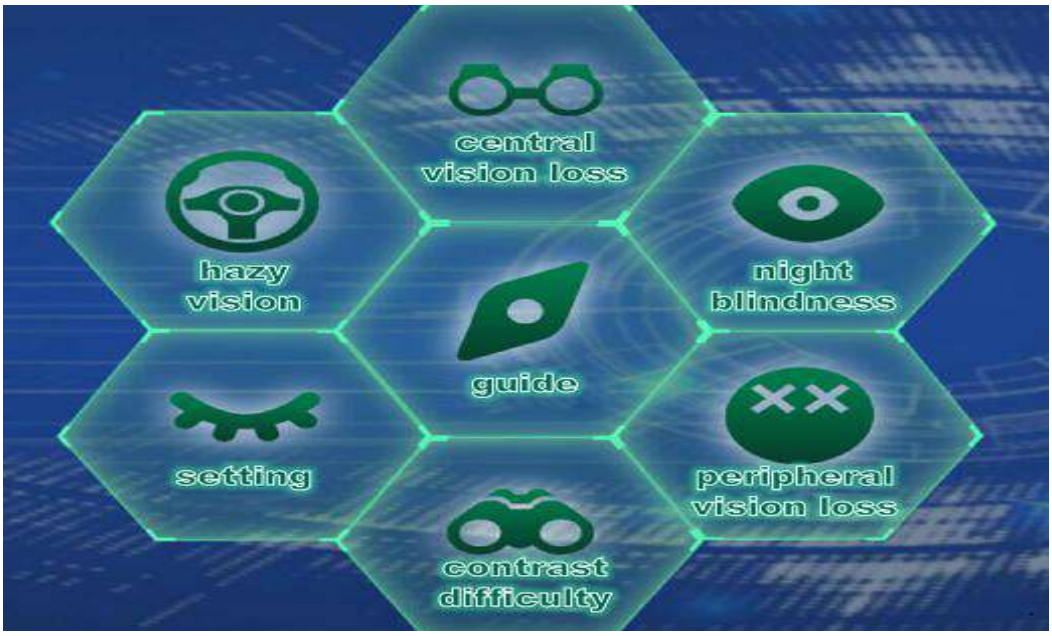

Fig 1: The main menu interface

Guide. Before the tasks begin, the users can learn instructions of the controls, even the function of each button. In this task, the users can take as much time as needed to get accustomed to moving and picking up objects in VR (See Fig. 2).

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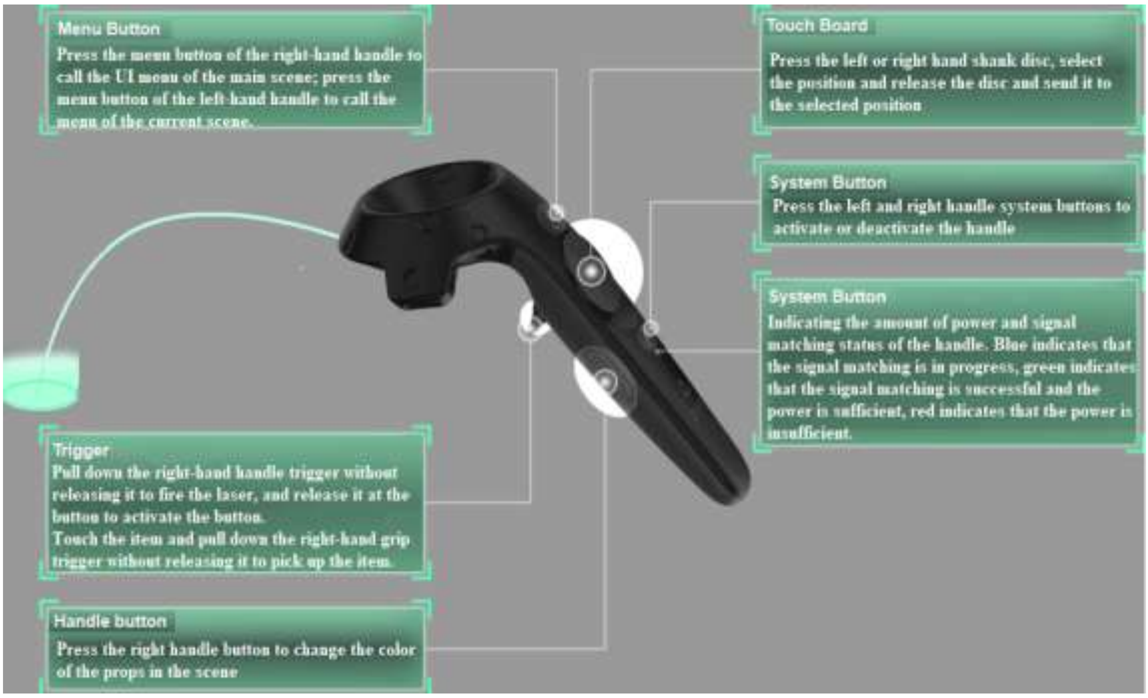

Fig 2: The instructions for the controls

Hazy Vision. Taking writing under the hazy vision task as an example, the user simulates the one with the hazy vision to be writing on the book. The task instructions are shown as text on the windows and explained by a voiceover. The User is required to write 3-5 words in the specified location. If the task fails, one can select the reset button (See Fig. 3).

Fig 3: Writing under the hazy vision

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Central Vision loss. Taking reading under the central vision loss task as an example, the user simulates the one with central vision loss as reading a newspaper. There is always a black spot in the center of sight. The user would be asked to read out a sentence highlighted with an underline in the center of his visual field within no more than 1 minute, and the completion criteria of the task were hinted at mainly by voiceover (See Fig. 4).

Fig 4: Reading under central vision loss

Night Blindness. Taking car driving under night blindness task as an example, with VR simulation, the user could experience the scenario of viewing light only but cars before, thus, the user would understand how scary and frightening someone with night blindness to go with the flow of traffic (See Fig. 5).

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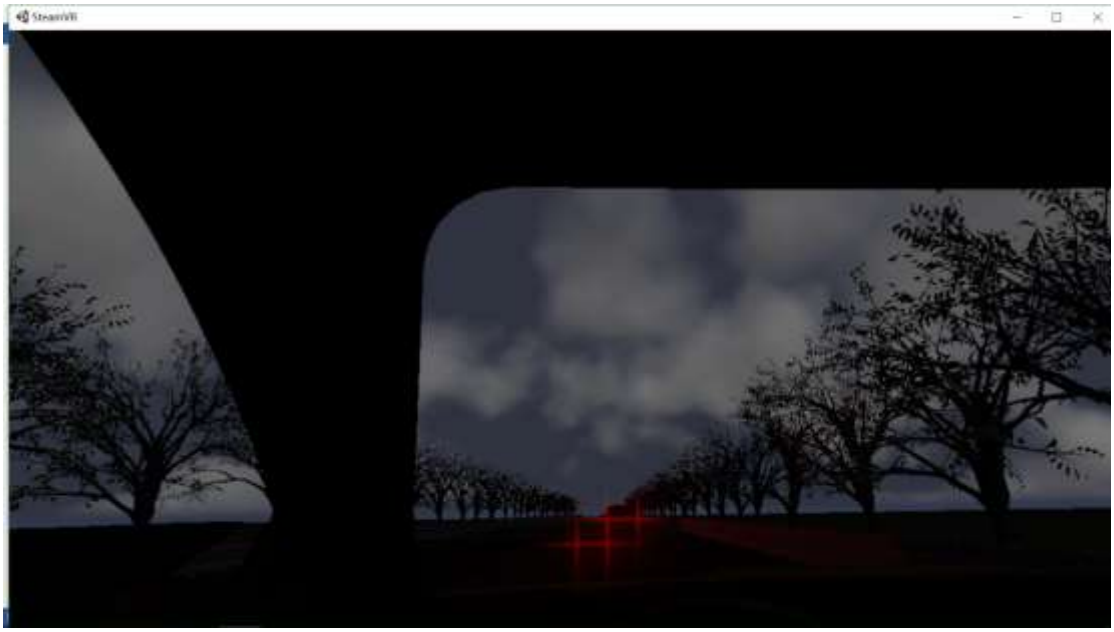

Fig 5: Car driving under night blindness

Peripheral Vision loss. Taking picking under peripheral vision loss task as an example, the user simulates the one with peripheral vision loss as picking and reading a newspaper. The User is required to pick up the newspaper in 15 seconds. If the task fails, can select the reset button (See Fig. 6)

Fig 6: Picking under peripheral vision loss

Contrast Difficulty. Take the car driving under contrast difficulty task as an example: Before the task begins, the user starts in an introduction room where the controls are explained, later, the user simulates

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the one with contrast difficulty is settled in a car, task instructions are shown as text on the windows and explained by a voiceover. Users with simulated contrast difficulty would be demanded to avoid oncoming cars with bright light, If the task fails, a scenario simulating a car accident would be shown (See Fig. 7).

Fig 7: Car driving under contrast difficulty

Results:

Fig 8: Experiencer under low vision simulation

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Upon use of this technique, The VR application narrows down the scenarios into 3 most commonly encountered tasks: reading, writing, and car driving. Participants would experience the challenges to complete these tasks under the impact of 5 simulated low vision symptoms. Thus, users would experience inconvenience or even danger the low vision face in daily life day by day. The low vision simulation in the virtual reality of our study requires a popular hardware device, with customized software, it could be fitted at regular equipped schools. It is promising to be applied in further empathy education for eyecare providers (See Fig. 8).

III. DISCUSSION

The VR application has offered much promise in many aspects of medicine, the highly immersive virtual environments and simulation make VR an innovative tool for medical training. Due to advantages tags like interactive, probable, safe, etc. upon VR, it has been widely utilized by physicians, medical students, and other healthcare providers for technique training, empathy training, therapy training, and even surgery training. [10, 16, 17]

Considering the growing demand of eye care providers facing an ageing society and drastic lifestyle changes, A few pieces of research published about VR application in the eye care field [18-20], and most of the current studies are focused on retina examination, eye surgery, eye anatomy, vision training of patients with strabismus or amblyopia. Overall, VR is scarcely witnessed in research exploring applications for eye health compared to other medical areas, especially, there is a lack of VR application for empathy education for eye care providers.

The toolkit presented in this paper is designed to develop a set of low vision simulation software, which is equipped with VR hardware meanwhile could be beneficial to empathy education within eyecare providers. The differences from the present studies are [11, 12], Our system combined the main symptoms of low vision and primary tasks troubled low vision mostly so that we could gain more simulations in virtual reality. Otherwise, we design each task in no more than 1 minute's serious game.

Our simulation-based on VR aims to educate and sensitize the normally sighted about the daily challenges the low vision face. This is particularly useful for eye care providers such as optometrists, ophthalmologists, vision rehabilitation therapists, mobility specialists, and potential eye care providers such as students related to specific areas. It is also helpful to normally sighted especially special education teachers, and low vision family members. Future applications of the simulator will assist kids with unhealthy lifestyles to protect their eyes.

There are also limitations in this study. First, the serious game with the task only may not promote users' interest strongly. Also, some users may experience dizziness using VR, so the time limits of the task should be strictly testified further. Last, the effectiveness of the simulation in empathy education for eye care providers should be further explored. Therefore, the toolkit still has many parts to be improved in the future. For instance, instead of fragmented tasks, we would try to design the scenarios related to low vision daily life into a story, the story may arise more intention and interest of people. Meanwhile, we would improve the quality of display by the higher PPD (Pixel Per Degree) both in VR headsets and virtual scenes. It should be noted that further study with cross-sectional study or even longitudinal randomized controlled design will be needed to confirm the effectiveness of the empathy training by VR technology, and, we may adjust the time limit carefully according to the research above. Once the toolkit is well accomplished, we would further assist in the design of software that addresses the vision training for low vision rehabilitation.

IV. CONCLUSION

In this study, we develop a toolkit of low vision simulation, with popular hardware on the market, users could experience the low vision daily struggles of living. We grouped 5 categories of low vision simulation (chief complaint of low vision) with mainly daily tasks (3 categories) filled with struggles. The application includes time constraints tasks and control challenges purposefully designed for any (potential) eye care provider use. We hope that this work will be further used to develop empathy for patients with low vision.

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